CarSolEl, a user-friendly tool to predict soil carbon stocks evolution in grassland-based farms

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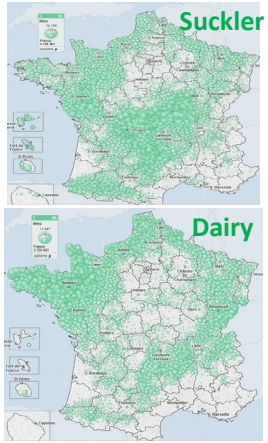
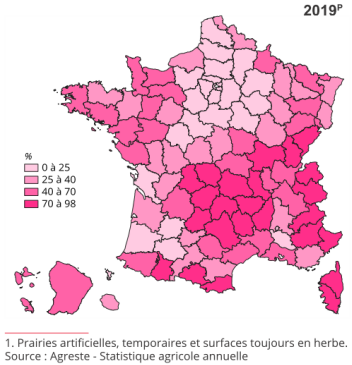
Context : French cattle are settled on C rich soil

Cows distribution

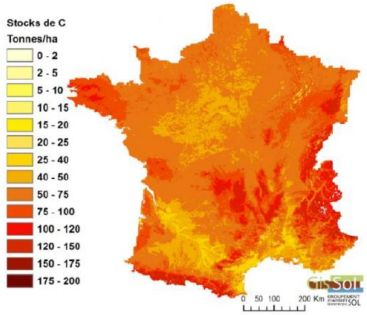


Grassland in agriculture area

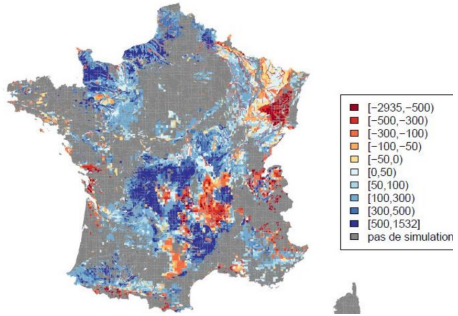


1. Prairies artificielles, temporaires et surfaces toujours en herbe.
Source : Agreste - Statistique agricole annuelle

Soil Carbon stocks (0-30 cm)



Permanent grassland C sequestration, main stream



PaSim, 0-30 cm, *In Pellerin et al. 2019*

- **Grassland occupies 44%** of french agriculture area ⇔ ruminant distribution
- **S**oil **O**rganic **C**arbon stocks **(SOC) are higher under permanent grassland** compared to arable
- **SOC evolution is highly variable : natural context and field management**
- **An increase in carbon stock is recommanded for food security and climate**
- **Support tools are needed to advice farmer on good management practices**

CarSolEl Project 2018-2022

- **CarSolEl** (funded by ADEME –INTERBEV-CNIEL)

  - Leaded by **Idele,** in collaboration with **4 INRAE units**
  - To create and transfer knowledge on soil C sequestration and modelling
  - **=> predict SOC evolution at field and farm scale in livestock area**

Combined with farm networks

- **What are farmers needs?**

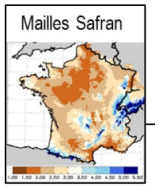
  - Farm approach : grasslands leys and permanent included
  - Reliable and sensitive to local conditions (soil, climate)
  - Feasible: easy to implement, quick results to designate trends
  - Descision support : simulate effects of changes in management on SOC and fertility

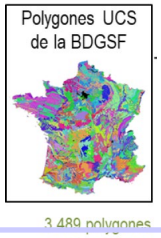
CarSolEl model: tool for farmers, advisors and researchers

- How do we proceed?

French national « 4p1000 » study

Fine spatial resolution (<1 km²)





Each unit is characterised by

- Soil & Climate
- Land use, crop leys
- Farm management

(Pellerin et al. 2019)

Research MODELS

STICS : *Crops and leys*
PaSim : *Perm. Grass.*

Soil carbon stock évolution
> 500 000 simulations

Models assessed on 3 long-term sites data then improved

CarSolEl — *Random Forest*

Few inputs data, easy to get on farm

To predict SOC changes

→ CarSolEl Metamodel(s)

Calibration 8o% dataset, validation 20% dataset

INSTITUT DE L'ELEVAGE idele INRAE ADEME

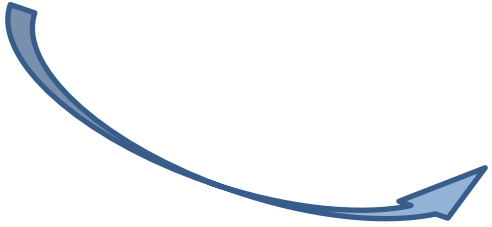
How to Run CarSolel ?

1 Gather field considering management and soil type

2 Select farm location on map

3 Check natural context

4 Fill in agricultural management



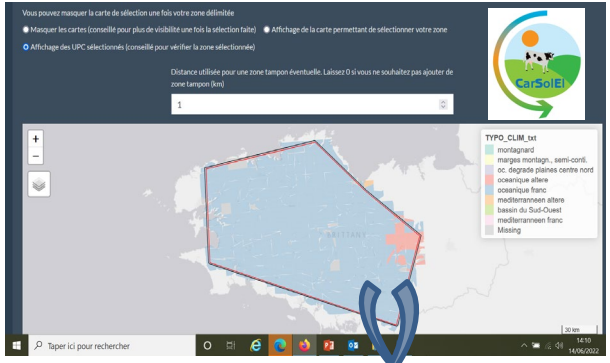
CarSoEl delivers the average trend over next 30 years

Kg C per hectare per year : upper soil layer (0-30 cm)

If negative value, organic carbon stock is declimbing

=> Test a change in management and see how it improves

Natural context Information



Climate zone (Joly D., 2010)

Annual rainfall (mean, mm/year)

Temperature (median, °mini, ° maxi)

Soil depht, coarse fraction,

If Soil analysis available, check

=> texture (%clay,...), pH, $CaCO_3$

=> Organic matter : SOC 0-30 cm

Data input requirements on Agri management

Consider several years to be representative

Fill in management

Cutting events and annual harvested yield

Number of grazing period, length, LSU/Ha

Chemical N and organic inputs (type and amount)

Nb of years with crops (resp. with grassland if leys)

Crop type, average yield

Fertilisation : chemical N and organic inputs

Sowing cover crop : frequency

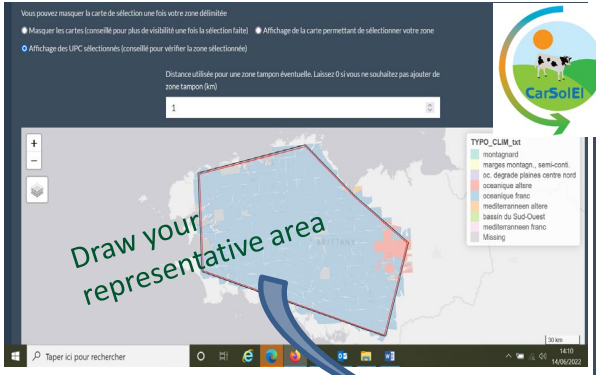
Irrigation (yes/no)

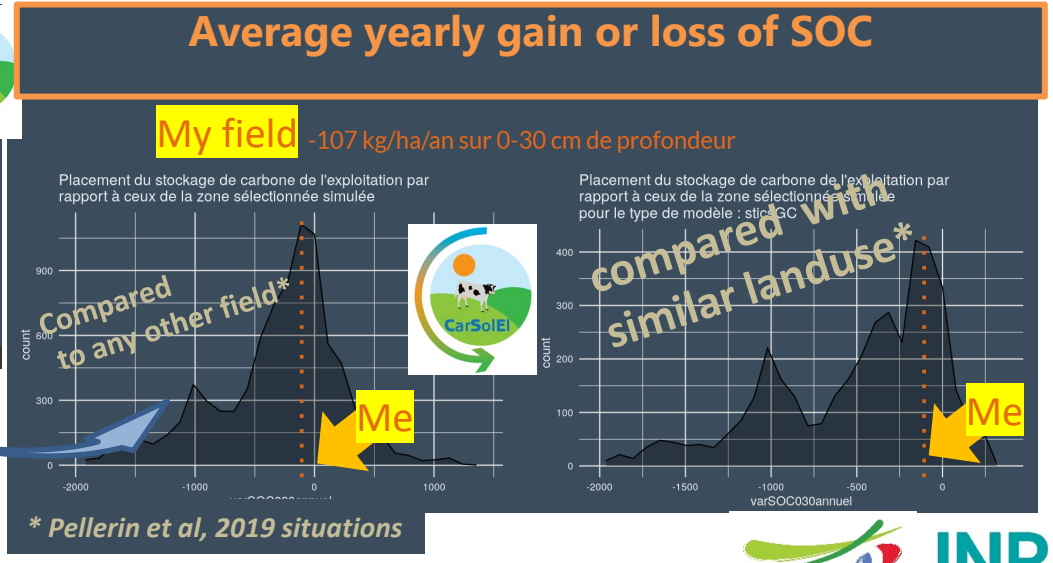
Result for one field type

CarSolel delivers

1 The trend with ongoing management: + is an increase in organic carbon stock, - is a decrease!

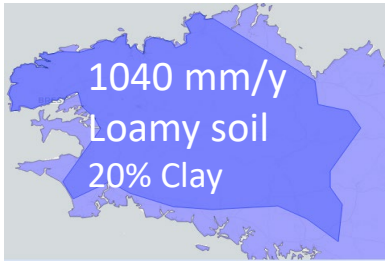
2 A comparison with other fields of the same area





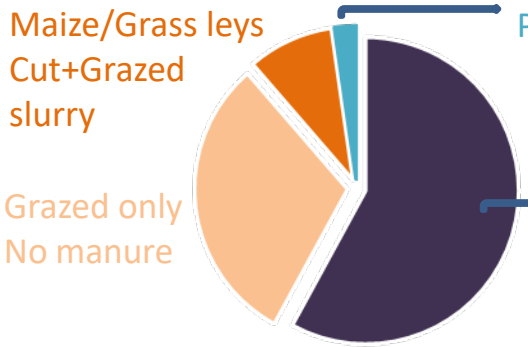
Final Result : an overview at farm scale of SOC trend

Case study dairy farm in western Brittany



1,7 LSU.ha^{-1} fodder area

30% cereals in AA



	Fertilizer input		Grass management		Soil Organic Carbon	
	Nmin KgN.ha^{-1}	Norg	Nb grazing days LSU d.ha^{-1} .yr^{-1}	Nb cuts .yr^{-1}	Init SOC tC. ha^{-1}	Delta C Kg C .ha^{-1}.yr^{-1}
Arable leys (crops)	65	100	-	-	85	**-234**
Grass. ley no manure	42	0	644	0	88	**-65**
Grass ley with manure	42	70	280	1	88	**+120**
Perm. Grassland	50	70	384	1	93	**+150**

Increase SOC
34% of AA

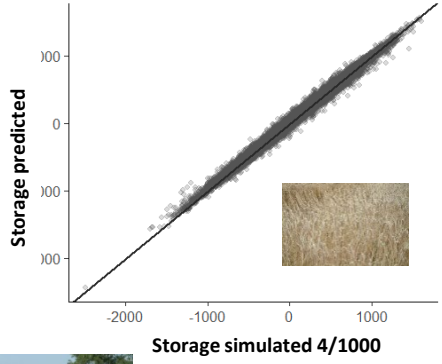
Quick but right

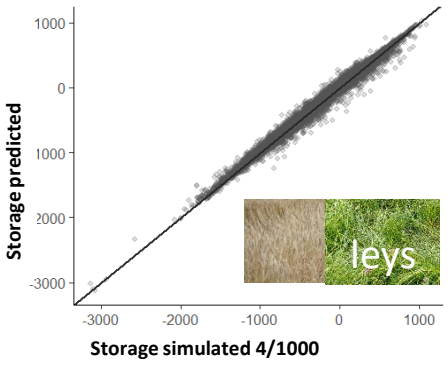
- What results?

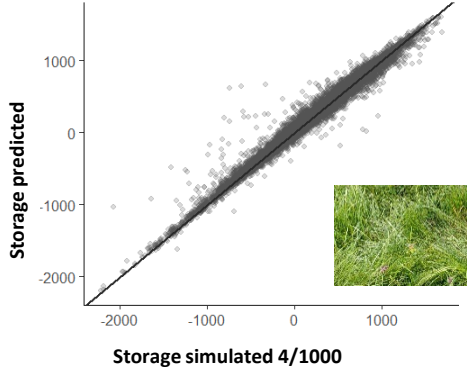
	Crops STICS GC	Leys STICS PT	Perm. Grassl. PaSim
Correlation	1	1	0.99
RMSE Kg C .ha^{-1}.yr^{-1}	30.44	36.16	57.09
MAE Kg C .ha^{-1}.yr^{-1}	16.97	24.49	32.26

Root mean square deviation RMSE

Mean absolute error (MAE)







Carsolel, further developpement

- What is next?

- **Internet web adress**

  =>http://appsonline.idele.fr/Carsolel/

- **Link to existing tools**

  as CAP2ER (Farm), Climagri (territory), possible inclusion in multicriteria assessment tools (LCA, …)

- Further improvement of models *(e.g. STICS grass module in 2022)*

  → updated version of metamodels in 'ongoing science'

Thank you for your attention

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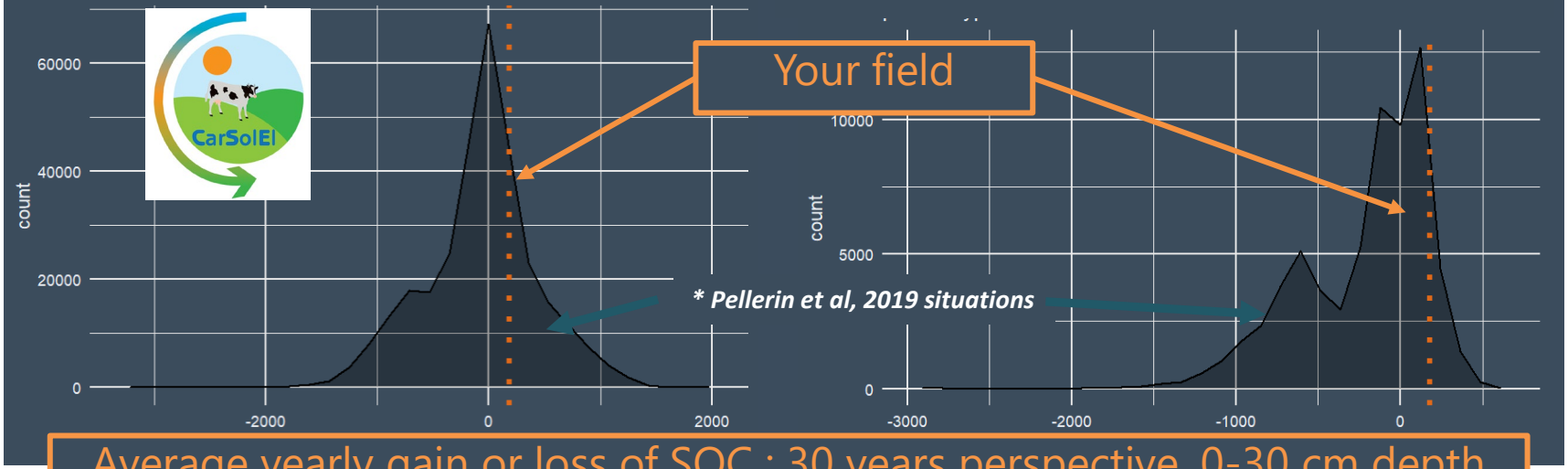
Ready to test the CarSolEl online access in september?
Please Contact helene.chambaut@idele.fr or any of co authors

Compare your field situation to others : local or regional database

Dark shape1 : **Any field*** in the selected area, whatever land use is

Shape2 : **Same type*** of management (i.e perm grassland, or Crops, or leys) in the selected area



Average yearly gain or loss of SOC : 30 years perspective, 0-30 cm depth